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HISTORY OF AVIATION AND COSMONAUTICS, VOL. IV

CONTENTS

IN MEMORY OF SERGEY PAVLOVICH KOROLEV

B.V. and M.K.

On January 14, 1966, in Moscow, died an outstanding Soviet designer and scientist, member of the Presidium of Academy of Sciences SSSR, Communist, Academician Sergey Pavlovich Korolev, who worked in the area of rocket and space technology. With his death Soviet and world science has lost a leading activist whose name is inseparably connected with the start of a new era of man's mastering of space. /3*

Sergey Pavlovich was born on December 30 1906 at Zhitomir, in the family of a teacher. Having enrolled in the Kiev Polytechnic Institute after receiving a secondary education, he transferred in 1926 to the third course at the Moscow Technical School of Higher Learning, and completed Department of Aeronautical Engineering in 1929. He combined his studies at the higher institution of learning with work in the aviation industry. /4

Having become enthused in problems of gliding and light-engine aviation, he, with his characteristic energy, completed pilot training in 1930 and simultaneously was engaged in designing gliders. In 1929, at the Sixth All-Union Glider Competition he was one of the designers of the "Koktebel" glider. In 1930 he designed and built the "Krasnaya Zvezda" glider on which pilot V.A. Stepanchenek was the first in the history of aviation to perform acrobatic maneuvers. Only a sudden illness prevented Sergey Pavlovich himself from completing these flights, outstanding for that time. In 1930 he made his first flight on the light-engine aircraft SK-4 which he designed. In 1935 Sergey Pavlovich participated in the second All-Union meeting of glider pilots as the pilot and designer of the two-place SK-9 glider, on which a liquid-fuel rocket engine was subsequently installed.

Sergey Pavlovich began his activity in the area of rocket engineering in 1930. Having become familiar with Konstantin Eduardovich Tsiolkovskiy and his works, Sergey Pavlovich devoted his entire life to accomplishing the bold dream of mankind--space exploration. The Group for the Study of Jet Propulsion (GSJP), founded with his participation, became the center in Moscow around which during the 1920s gathered rocket engineering enthusiasts. From that time until the end of his life he devoted all his efforts to development of Soviet rocket and space technology.

Sergey Pavlovich, heading the GSJP team since 1932, worked hard and fruitfully on the design of the first experimental engine and rockets and solved a number of theoretical problems. In 1934 he gave a report on the flight of jet craft in the stratosphere at the All-Union Conference for the Study of the Stratosphere at Leningrad.

*Numbers in the margin indicate pagination in the foreign text.

After organization of the Jet Research Institute at the end of 1933, S.P. Korolev accomplished considerable organizational, research, and design work at this Institute, directing his creative efforts to the development of long-range, /5 winged guided missiles and rocket aircraft.

Considering that one of the main purposes in the development of rocket engineering was to create craft capable of lifting man, he personally flew, while still in the GSJP, the BICh-II tailless glider designed by B.I. Cheranovskiy on which a rocket engine was subsequently mounted. The project of mounting such a motor on a glider could not be accomplished at that time, but in 1940 pilot V.P. Fedorov flew the abovementioned SK-9 glider with a liquid-fuel rocket engine mounted on it. Thus, the first manned flight on an aircraft with a liquid fuel rocket engine, still within the atmosphere, was accomplished on an aircraft designed by S.P. Korolev.

During the second World War S.P. Korolev worked on the installation of liquid-fuel jet boosters on fighters and dive bombers and personally participated in test flights.

Sergey Pavlovich later worked intensely on the theory and practice of rocket engineering, from time to time combining his work with teaching at institutes of higher learning.

S.P. Korolev was the designer of space rocket systems on which the world's first launchings of artificial earth satellites were accomplished, including the launching of the first satellite on October 4 1957, the delivery of the Soviet emblem to the moon, and the fly-by and photographing of the far side of the moon, which in essence meant the creation of new, experimental astronomy together with the long-existent observational astronomy.

Spaceships were created under the supervision of S.P. Korolev on which equipment was worked out for manned flight into space and for the return of the spacecraft to earth, as well as the piloted space ships "Vostok" and "Voskhod" on which man, for the first time in history, completed a flight into space and the first space walk.

Sergy Pavlovich taught numerous scientists and engineers who are presently working at many research institutes and design departments in the area of rocket and space technology. He had many pupils and followers.

Inexhaustible energy, talent as a scientific researcher, magnificient en- /6 gineering intuition, great creative boldness in solving the most complex scientific and technical problems were combined in S.P. Korolev with brilliant organizational abilities and high personal qualities.

S.P. Korolev was highly respected and won the esteem of all who worked with him. In 1953 he was elected a corresponding member of the Academy of Sciences of the USSR, and in 1958 an Academician.

The fruitful activity of Sergey Pavlovich Korolev earned the gratitude of the Soviet people and was marked by high government awards. For outstanding service to the Motherland he was twice awarded the title of Hero of Socialist

Labor, winner of the Lenin Prize, and was awarded orders and medals of the Soviet Union.

S.V. Keldysh, president of the Academy of Sciences of the USSR, stated that the name of S.P. Korolev "will always be related with one of the most outstanding victories of science and technology of all times--the opening of the era of man's conquest of space," and that Academician S. P. Korolev "belongs to those remarkable scientists of our country who have made an indelible contribution to the development of world science and culture."

We cannot help but be sorry that death has terminated his activity and that he will not be able to enjoy the latest achievements of astronautics to which he devoted his entire efforts.

The memory of Academician Sergey Pavlovich Korolev, a true son of the Communist Party, who selflessly served his Motherland, will always be preserved in our country.

PRACTICAL SIGNIFICANCE OF THE SCIENTIFIC AND TECHNICAL PROPOSALS OF K.E. TSIOLKOVSKIY IN THE FIELD OF ROCKET ENGINEERING*

S. P. Korolev

ABSTRACT. A brief history of the contributions made by K. E. Tsiolkovskiy, father of Russian rocketry. The author reviews the contributions of Tsiolkovskiy to present day rocket technology.

In our day rocket engineering is one of the leading areas of modern science /7
and technology. The time has long passed since the remote concepts of "fiery arrows" of ancient China and India, of the rocket missiles of the Englishman Congrew and Russian general K.I. Konstantinov were associated with rockets.

During the years of the second World War the mortar units of the Soviet Army armed with solid-fuel rocket projectiles often, while protecting our Motherland, subjected the horde of Fascist bandits to annihilating destruction.

During the post-war years aircraft with jet engines of different types became increasingly more widespread. The jet express TU-104 flies the airlines. New, remarkable models of high-speed jet aircraft have been created; significant flying speeds and altitudes have been achieved by aircraft; the so-called "sound barrier" has been left far behind. Two types of aircraft, and in particular, military aircraft, are being developed, generally with jet engines.

In high-speed aviation a transitional critical period, so to speak, has presently arisen--from aircraft to rocket. Soviet pilots for the first time in history have flown aircraft with liquid-fuel jet engines.

Extensive investigations of the upper layers of the atmosphere and space above the atmosphere are being carried out by the Academy of Sciences of the
USSR in vertical launchings of high-altitude rockets. Complex research equip- /8
ment and experimental animals are being carried aloft in rockets and returned to earth. Soviet rockets are making flights at very great altitudes above the earth's surface which no one has yet reached.

The Soviet Union is successfully testing super long-range, intercontinental, multistage, ballistic rockets. The results obtained show that it is possible to launch rockets to any region of the earth.

During the period of the now approaching International Geophysical Year dozens of rockets will be launched to conduct scientific investigations according to diverse programs for different altitudes and in different regions of the

*A report given by S.P. Korolev on September 17 1957 at the ceremonial assembly meeting of the Academy of Sciences of the USSR devoted to the One-Hundredth Anniversary of the birth of K. E. Tsiolkovskiy. An abridged verbatim report is published.

Soviet Union, including regions of the Far North and Soviet expeditions to the Antarctic.

In the near future the first test launchings of artificial earth satellites will be carried out in the USSR and USA.

Soviet scientists are working on many new problems of rocket engineering, for example: on the problem of sending rockets to the moon and lunar fly-by, on the problem of manned flight in a rocket, on problems of deep penetration and investigation of space.

This is far from a complete review of the outstanding events in the area of scientific and technological progress associated with the development and achievements of rocket engineering in the Soviet Union during the past 15-20 years.

The remarkable predictions of Konstantin Eduardovich Tsiolkovskiy concerning rocket flight and flights into interplanetary space which he expressed more than 60 years ago, are coming true.

Konstantin Eduardovich wrote with enormous force and conviction in one of his letters: "Man will not remain eternally on earth, but in the pursuit for light and space, he will at first timidly penetrate beyond the limits of the atmosphere and then conquer all solar space."*

The most remarkable, bold, and original creations of Tsiolkovskiy's creative mind were his ideas and works in the area of rocket engineering. Here he had no predecessors and far outstripped scientists of all countries and was far ahead of his time.

Konstantin Eduardovich Tsiolkovskiy was a scientist and experimenter, self- /9
educated, who by his untiring labors independently raised science and scientific foresight to extraordinary heights. He was an inventor who affirmed the priority of our Motherland by a number of outstanding inventions and technical proposals in the area of gliding, aviation, and especially in the field of rocket engineering, which now has such topical importance.

He was a scientist and researcher who boldly paved the way to the new, still uninvisioned in science, and as a true scientist he brilliantly, scientifically substantiated his discoveries. And, finally, he was an ardent patriot of the Soviet Motherland, an indefatiagable worker and eager enthusiast of science, to which he wholly devoted and gave his life.

In 1873 the 16-year-old Tsiolkovskiy went to Moscow. During his Moscow period the general direction of future endeavors, technical ideas and works which Tsiolkovskiy subsequently followed during his entire life, was mapped out.

This pertains to his thoughts as to whether various properties of matter could be used for realizing some type of moving apparatus. Thoughts of gravity and means of combatting gravity occupied Tsiolkovskiy.

*Letter of K. E. Tsiolkovskiy to B. N. Vorob'yev dated August 12 1911 (Archive of the USSR Academy of Sciences).

Thus, even then, vague ideas about the possibility of manned flight beyond the limits of the earth's gravity or, as he himself subsequently stated, "fascinating dreams," took form in Tsiolkovskiy's conscience. The first projects proved to be failures, the first attempts to invent ended unsuccessfully, but this did not cool the energy of Tsiolkovskiy.

Many years of persistent work passed, agonizing doubts in complete solitude, without support, without any sympathy, and often with outright disproval and even mockery addressed to the queer, half-deaf school pupil and "mad inventor," which Tsiolkovskiy was considered by the local officials and bureaucratic top eschelon of the engineering and technical strata of tsarist Russia.

In 1883, in his work "Free Space," which was a unique scientific diary, Tsiolkovskiy examines the occurrence of the simplest phenomena of mechanical motion in space without the effect of gravity and drag.

Examining methods of imparting motion to a body in free space, Tsiolkovskiy arrived at his most basic and important fundamental conclusion, that it is simplest to impart motion to a fixed body (or to change motion) by thrusting a mass backward, i.e., by the reaction of particles thrust from a given body. This is what Tsiolkovskiy writes in his work "Free Space": /10

"28 March 1883. Morning.

...let us assume that we have a barrel filled with a strongly compressed gas. If one of its thinnest stopcocks is turned, then the gas will rush from the barrel in a continuous stream, whereby the pressure of the gas repelling its particles into space will also continuously repel the barrel.

"The results of this will be a continuous change of motion of the barrel.... By means of a sufficient number of stopcocks (6) it is possible to control the escape of gas so that motion of the barrel or the hollow sphere will depend completely on the desires of the one controlling the stopcocks, i.e., the barrel can describe some desired curve and obey some desired law of velocities....

"The motion of the barrel can be changed only until all gas has escaped from it.

"...In general, uniform motion over a curve or rectilinear, nonuniform motion is associated in free space with continuous loss of matter (support)."*

Thus, the principle of jet propulsion was developed by Tsiolkovskiy at the very beginning of his independent scientific activity.

In the article "Free Space" there are no quantitative results, or findings are constructed on qualitative conclusions from the law of conservation of momentum for closed mechanical systems, but the expediency of using the reaction of an escaping stream for motion in free space is formulated distinctly and clearly.

K.E. Tsiolkovskiy: Collective works, Vol. II. Moscow, Izd-vo AN SSSR, p. 52, 1954.

In 1896 Tsiolkovskiy finally arrived at the conclusion that the only technical means for flight into outer space is the rocket. In 1903 Tsiolkovskiy published his work "Investigation of World Space by Jet Apparatus." This classical work is rightfully considered the world's first scientific work devoted to problems of the theory of motion and to a variety of important fundamental technical proposals in the area of rocket engineering. /11

Tsiolkovskiy saw the vast future in the development of rocket engineering, but simultaneously he clearly understood what difficulties had to be faced. He wrote: "...as a researcher of the atmosphere I propose a jet apparatus, i.e., a kind of rocket, but one that is grandiose and specially constructed. The idea is not new, but the calculations pertaining to it give such remarkable results that it would be impermissible to fail to mention them.

"This work of mine far from examines all aspects of the matter and does not solve it at all from the practical point of view relative to feasibility; but in the far future the prospects, so alluring and important that even now one can dream about them, are already apparent through the haze."*

In supplements to this work published in 1911-1912 and 1914 and later, and in numerous works, articles, projects, and manuscripts on which Tsiolkovskiy worked until the last days of his life, he examined a wide range of problems of a theoretical, research, and design nature, as well as numerous problems having applied technical, design, and technological values.

In developing theory and in investigating laws of rocket motion Tsiolkovskiy held to a strict sequence in his works. At first he solved the simplest problem on the assumption that during rocket flight there was no force of gravity of drag. This problem is now called Tsiolkovskiy's first problem.

He introduced the hypothesis of the constancy of the relative rate of rejection of particles for certain substances. This hypothesis is called Tsiolkovskiy's hypothesis.

He wrote the basic equation of motion of a rocket in a medium without the effect of external forces, known as Tsiolkovskiy's formula. In this equation the ratio of fuel weight to the end weight of the empty rocket is called the Tsiolkovskiy number. He wrote a number of theorems bearing his name.

When calculating rocket motion a complicating factor is the appreciable change in mass of the rocket apparatus during travel. This condition does not permit using formulas of classical mechanics for calculation. An unquestionable service of Tsiolkovskiy in developing rocket theory was the elaboration of a number of applied problems of a new section of classical mechanics--mechanics of bodies of variable mass--which he accomplished independently of other similar works. /12

Having examined rocket motion in a medium without the effect of external forces, Tsiolkovskiy thoroughly investigated the effect of the forces of gravity and drag on rocket flight. It is necessary to point out a characteristic

K.E. Tsiolkovskiy: Collected works, Vol. II, p. 73.

feature of Konstantin Eduardovich--he was a persistent battler for overcoming the forces of gravity, he considered the force of earth's gravity to be, so to speak, a chain binding mankind to the surface of our planet. He called the range of action of gravitational forces the armor of gravitation.

In almost all his works Tsiolkovskiy inevitably returned to the problem of combatting gravity. He conducted investigations and calculations to determine fuel reserves needed to overcome the armor of gravitation and to find those optimal conditions under which energy expenditure during takeoff of a rocket would be minimal.

An appreciable place in his investigations is occupied by the problem of the effect of drag on rocket motion, fuel supplies, and the most advantageous flight conditions necessary to penetrate the earth's atmosphere. Tsiolkovskiy called the range of action of drag the armor of the atmosphere.

In his theoretical works Tsiolkovskiy arrived at a variety of major conclusions which even today are widely employed in rocket engineering.

Furthermore, as practical works developed and rocket engineering improved, increasingly more conclusions and hypotheses of Konstantin Eduardovich, which he expressed long ago, were verified.

His investigations showed that velocity, and, hence, range of rocket flight increase with an increase of the relative supply of explosives (fuel) on board the rocket. By supplying them in different quantities, it is possible to achieve any terminal velocity and any range.

Velocity at the end of combustion (at the end of the powered flight of the rocket) proves to be more, the higher the relative speed of the rejected particles. The speed of the rocket at the end of the powered section of the trajectory also increases with an increase in the ratio of initial rocket weight to its weight at the end of combustion. /13

A quite important practical conclusion follows from the Tsiolkovskiy formula: higher rocket speeds can be accomplished more effectively by increasing the relative speeds of the ejected particles, i.e., by improving the power plant, then by increasing the relative fuel supply on board the rocket, i.e., by improving its design.

Tsiolkovskiy was the first to determine the degree of utilization or efficiency of a rocket, having indicated the advantage of using rocket engines only at high speeds. Examining problems of using liquid-fuel rockets for flight in the dense layers of the atmosphere, he arrived at negative conclusions.

Tsiolkovskiy performed investigations and calculations pertaining to rocket launch and selection of optimal launch conditions and examined a vertical launch, inclined launch, and launch from a prescribed initial height.

He performed the first calculations to select the best angle of climb with consideration of losses to overcome forces of gravity and drag during flight in a medium having a variable density, change of the altitude characteristics of an engine, and many other calculations and investigations.

A special feature of the creative method of Tsiolkovskiy lay in the thorough, practical elaboration of each problem examined. Under conditions of tsarist Russia Tsiolkovskiy had limited opportunity for experimenting, he did not have at his disposal either equipped laboratories, or experimental stands, or design departments and factories. He did not have assistants, and extreme independence and self-dependence were characteristic of him.

But he did not simply theorize; with exceptional insight and depth he supplemented all his, sometimes highly unusual, theoretical conclusions with such earnest and detailed practical considerations that a vast number of them found use and are widely employed even today in all countries of the world engaged in rocket engineering.

Here are some of the most interesting of these problems. Konstantin /14
Eduardovich thoroughly investigated rocket energetics, selection of fuel for engines, and their construction. He formulated the basic requirements for fuels and hypotheses on the selection of fuel in terms of the highest energy producers per unit mass, highest possible density of the fuel, and in terms of a number of other characteristics. Tsiolkovskiy settled his selection on liquid fuel with the use of liquid oxygen, liquid hydrogen, and petroleum and its derivatives.

He proposed a special detonation tube in the form of an expanding cone and combustion chamber to which the fuel was delivered by pumps, and proposed automatic control of combustion processes in the motor so as to regulate its operating conditions with the specific conditions of rocket travel over a trajectory.

In order to create the most favorable conditions for fuel combustion, he had in mind the establishment of a grid with oblique aperture at the inlet to the detonation tube. Tsiolkovskiy suggested that it was best to determine the number, size, and slope of the apertures in the grids by experiment.

Problems of cooling the blast tube where extremely high temperatures should develop brought up special dangers. This problem was to be solved by cooling the tube by the fuel components or by some liquid metal situated in a special jacket.

Tsiolkovskiy very thoroughly investigated ways of protecting the blast tube against the effect of high temperatures, examined various materials for manufacturing the tube, and proposed to protect it by refractory or heat-resistant materials.

He determined the powers required for pump operation at different combustion pressures and supply systems, and also investigated processes of delivery, atomization, ignition, and combustion of fuel.

In Tsiolkovskiy's works we can find mention of the probable use of atomic energy, solar energy, and energy of cosmic radiation to impart motion to the rocket.

However, he qualified his calculations by stating that they did not produce the desired results and that, although all discoveries are possible and dreams can unexpectedly be fulfilled, in his works he wants to stand as much as possible on practical soil.

Tsiolkovskiy expressed the interesting thought of controlling rocket flight by using the energy of a stream of escaping gases. He proposed a device for turning the end of a branch pipe of the blast tube, or a gas rudder in the form of plates installed in the gas stream. /15

Tsiolkovskiy foresaw that manual control of a rocket flight would be not only difficult but practically impossible. Therefore, automatic equipment and gyroscope instruments ought to be installed on board a rocket to generate the necessary control signals. Orientation in space during rocket flight could be accomplished automatically by a servo system using magnetic properties or fixed on the sun or on some star.

At the same time he proposed air rudders, elevators, and something not unlike ailerons designed for operating when the rocket flies in sufficiently dense layers of the atmosphere.

Tsiolkovskiy elaborated a variety of interesting problems related with rocket design, selection of its shape, internal components, arrangement of mass within the rocket, and possible systems of various power and hermetic connections with consideration of their operating conditions in flight.

He proposed the use of internal pressure in the rocket to increase its strength and examined the problem of maintaining and controlling pressure drops within the most suitable limits, which, in turn, he related to the problem of decreasing the passive weight of the rocket at the end of burning. He investigated the conditions and possible regimes of rocket heating as the rocket moved in the dense layers of the atmosphere and proposed various schemes for cooling and heat protection.

As Tsiolkovskiy developed his self-contained rocket he never gave up the thought that flight velocities would be reached which would permit overcoming earth's gravity and manned flight in a rocket into space. This aspiration permeates through all of Tsiolkovskiy's works. His designs of sectional, multistage rockets, and rocket trains, which he pondered a very long time ago, are remarkable and grandiose.

This is what Tsiolkovskiy wrote in 1929 in his work "Space Rocket Trains":

"By rocket rain I mean the connection of several identical jet apparatus moving at first along a track, then in air, then in the vacuum outside of the atmosphere, finally, somewhere between the planets or suns. /16

"Not only is a part of this train carried away into celestial space, but the remaining parts, not having sufficient speed, return to earth.

"A self-contained rocket must be given a large fuel supply to reach escape velocity; this hampers the construction of jet apparatus.

"A train makes it possible either to reach high speed velocities, or to limit oneself to a comparatively small supply of the blasting constituents."*

Tsiolkovskiy investigated the basic technical and flight characteristics and the initial data and parameters of sectional, multistage rockets in different versions.

It is difficult to overestimate the value of Konstantin Eduardovich's proposals for sectional, multistage rockets, and rocket trains. In essence this proposal opened space to man.

The foregoing individual sections of Tsiolkovskiy's works, which abound in a mass of technical details, proposals, and ideas, are organically related in his works with theoretical concepts and proofs. Very much of this is already being used and is in no way unusual and it is self-evident.

Indeed, isn't the use of a rocket as a flying vehicle, liquid oxygen as one of the fuel components, and, for example, gas rudders for flight control obvious now, in our time. And all this was proposed by Tsiolkovskiy 60 years ago when heavier-than-air craft still did not exist and a rocket was only a pyrotechnic toy.

Today the Soviet community is celebrating the One-Hundredth Birthday Anniversary of the outstanding scientific worker in the field of rocket engineering and astronavigation, Konstantin Eduardovich Tsiolkovskiy. Soviet scientists will remember and praise his ideas, labors, and works, and will creatively develop and continue them. /17

The most interesting and fascinating section in the works of Konstantin Eduardovich is that pertaining to the problem of interplanetary travel. It would be more correct to say that almost all the works of Tsiolkovskiy are purposefully directed and related with the theme of interplanetary flights.

Even his works on jet apparatus for flight in the atmosphere Tsiolkovskiy regarded only as a step toward flight into space. He predicted that the era of propeller aircraft would be followed by jet stratoplanes and, finally, rocket trains of the future and artificial earth satellities in the form of habitable interplanetary stations.

With the appearance and development of the idea of sectional, multistage rockets, and rocket trains, the problem of space flight with the use of presently known chemical energy sources became a sufficiently real technical problem.

K. E. Tsiolkovskiy: Collected works, Vol. II, pp. 299-300.

Tsiolkovskiy conducted extensive investigations and calculations pertaining to problems of flight of an interplanetary rocket beyond the limits of earth's gravity, its further motion in free space, and the possibility of return to earth. He determined the optimal conditions of such flights under the most diverse variants and with different initial data.

Tsiolkovskiy was the first to investigate various trajectories and characteristics of different orbits of space rockets during takeoff from the earth and from the surface of planets and asteroids.

He examined the probable life conditions of future interplanetary travelers in a rocket. To protect people against the effect of acceleration during takeoff and braking of the rocket, he proposed to submerge them in special suits into tanks with a liquid having a density close to the density of the human body.

Foreseeing that a long stay in a medium without gravity would be difficult for the human organism to endure, Tsiolkovskiy proposed to create an artificial field of gravity during flight in an interplanetary rocket or artificial earth satellite.

Tsiolkovskiy again returned to the idea of using the sun's radiant energy for supplementing the energy reserves of an interplanetary rocket and for using this energy on an artificial interplanetary station, especially if it was inhabited for a long period of time. /18

The problem of available energy supplies became especially acute to Tsiolkovskiy in connection with the development of the problem of returning to earth, or, if the need arise, landing on one of the planets with subsequent takeoff from it and then descent to the earth.

Tsiolkovskiy proposed a very interesting solution to the problem of landing a rocket on the earth almost without the consumption of fuel. In this case, the rocket, entering the earth's atmosphere, is braked, moving over an orbit around the earth for a time sufficient for the enormous entry velocities to decrease while maintaining in so doing regimes of heating and g-forces during deceleration acceptable for the rocket. This idea was later developed by Yu. V. Kondratyuk, a follower and pupil of Konstantin Eduardovich.

Tsiolkovskiy placed strong emphasis on the problem of developing interplanetary stations. In solving this grandiose problem he saw not only the enormous fundamental facilitation for heights of space rockets, which according to his opinion should be based on these stations, not only a magnificent scientific achievement, but also the possibility of realizing his long-held dream of man's actual conquest of solar space.

Tsiolkovskiy proposed to construct the interplanetary station itself out of several rockets connected together after entering orbit; it was to be well-equipped, spacious, flooded with sunlight, and without the burdensome restrictions of earth's gravity.

By burning a small quantity of fuel, as the need arose, it was proposed to change the orbit of the interplanetary station. Communication of the station with the earth, according to Tsiolkovskiy, could be maintained by special rockets.

Takeoff of space rockets from the region of the interplanetary station would occur under greatly facilitated conditions, just as their landing upon return, since it would be possible to add to the rocket fuel stored beforehand on the interplanetary station.

Tsiolkovskiy proposed a scheme of a heating device providing different temperatures in the living quarters of the interplanetary station, using solar heat. /19

Here is what he said with respect to this: "The opaque part of the living quarters is black on the outside. At a small distance from it is a second skin shiny on both sides. Its parts can rotate and become normal to the surface like the quills of a porcupine. Then a lower temperature is obtained. When this armor covers the black surface, a higher degree of heat is obtained. This skin can also be placed on the transparent part of the living quarters. Then a lower temperature can be produced. Depending on the purpose of the etheral chambers, their construction can be be very diverse.

"...At first there will be simple homes suitable both for people and for plants. They will be filled with oxygen having a density of 1/5 of the atmosphere, a small quantity of carbon dioxide, nitrogen, and water vapor. Here will be some fertile and moist soil. It, illuminated by the sun and sown, can produce root crops and other plants rich in nutrients. People by their respiration will spoil the air and eat the fruits, but the plants will purify the air and produce fruits."*

"The energy of solar rays can be used for existing for an indefinitely long time without an atmosphere or planet. Just as the earth's atmosphere is purified by plants by means of the sun, so also can our artificial atmosphere be regenerated....Just as there is an infinite mechanical and chemical turnover of matter on the earth's surface, so also can this turnover be accomplished in our small world....

"[Calculations show] that one square meter of greenhouse facing sunlight is sufficient to feed a man. But who prevents us from taking a greenhouse having an enormous surface in a compacted form, i.e., in a small volume!?

"When circular motion around the earth or sun is established, we will assemble and move out from the rocket our airtight cylindrical boxes with diverse plant sprouts and suitable soil."**

Thus, the necessary life support conditions will be provided on an interplanetary station for a sufficiently long time.

*K.E. Tsiolkovskiy: Collected works, Vol. II, p. 253.
**K.E. Tsiolkovskiy. Collected works, Vol. II, pp. 128-130.

But gravity! Is it a necessary condition for plant life? In all probability no, because as experiment shows a change in direction and of the force of gravity by centrifugal force does not destroy the process of plant life. /20

Tsiolkovskiy did not doubt the possibility of man living in space provided certain conditions were created.

Rockets were known and the launching of pyrotechnic rockets had been observed by many long before Tsiolkovskiy. However, only Tsiolkovskiy proposed a jet apparatus similar to a rocket as a new and technical means for achieving unprecedented speeds and heights and for takeoff into the boundless world of the cosmos. Herein lies the greatness of Tsiolkovskiy's talent, his exceptional originality and distinction.

Tsiolkovskiy expanded the limits of human knowledge, his ideas about penetrating space in a rocket are only now beginning to be recognized in all their grandeur.

Konstantin Eduardovich labored the greater part of his life, under the severe situation of Tsarist Russia, surrounded by an insurmountable wall of ignorance and indifference.

He wrote: "The main purpose of my life was to make something useful for people, not to waste the gift of life, to advance mankind if only a little bit. This is why I was not interested in whether bread or help was offered me. But I hope that my works, perhaps soon and perhaps in the far future, will give society a mountain of bread and a store of power."*

The Great October Socialist Revolution was that powerful force which inspired the 60-year-old Tsiolkovskiy with new creative daring and offered him unheard of opportunities. His name and his works have become known and are close to the Soviet people. In his declining years, suffering with disease, Konstantin Eduardovich took to his work with great enthusiasm.

He lived long enough so that his cherished thoughts of rockets and man's exploration of stellar space ceased to be considered an unrealizable fantasy and became a scientific and technical problem of our time.

Tsiolkovskiy bequeathed all his works on aviation, rocket navigation, and interplanetary communications to the Bolshevik Party and Soviet power--the true leaders in the progress of human culture. /21

Today we can say that the scientific legacy of Tsiolkovskiy, given to the Bolshevik Party and Soviet power, is not being left on the shelf and is not being utilized dogmatically, but is being creatively developed and successfully continued by Soviet scientists.

At present, obviously, it is still impossible to fully evaluate the entire

*K. E. Tsiolkovskiy. First Model of a Purely Metallic Aeronaut of Corrugated Iron. Kaluga, p. 1, 1913.

significance of the scientific ideas and technical proposals of Konstantin Eduardovich Tsiolkovskiy, especially in the area of penetration into interplanetary space.

Time sometimes inexorably wipes out the traces of the past, but the ideas and works of Konstantin Eduardovich will always attract increasing attention as rocket engineering develops.

Konstantin Eduardovich Tsiolkovskiy was a man who lived long before his era and we should recognize him as a true and great scientist.

N68-13576

THE FIRST ROCKET AIRCRAFT IN THE USSR*

K. I. Trunov

ABSTRACT. The activity of S. P. Korolev, designer of gliders that could carry rocket engines; the SK-9 (with engine the RP-318-1) rocket-propelled glider equipped with the RDA-I-150 rocket engine was successfully tested on February 28, 1940, by test pilot T. Fedorov.

The glider "Koktebel'" was presented in 1929 at the Sixth All-Union Glider Competition held in Crimea and caused bewilderment in the participants of the competition. On one hand, this glider was distinguished by its beautiful aerodynamic forms and, on the other hand, had the largest load per square meter, 18.8 kg. It was 50-90 kg heavier than its competitors. It contradicted the basic laws of gliding, since it was considered that for good soaring a glider should have a small weight and small load per square meter. The designer of the glider, Sergey Pavlovich Korolev, tested it himself, remaining in the air 4 hours and 19 minutes. The glider flew no worse than its lighter competitors, had a high horizontal speed, good stability, and was quite controllable. /22

Why the designer of the "Koktebel'" glider increased the wing load remained incomprehensible to all.

In 1930 the participants of the next, Seventh All-Union Glider Competition were startled by the data of S. P. Korolev's glider "Krasnaya Zvezda" (SK-3). This glider had a load per square meter of 22.5 kg. This was so unusual that it was doubted whether the glider "Krasnaya Zvezda" could soar in the air at all. The weather prevented the competitions. Finally, on October 28 the wind started, reaching 15 m/sec, but the stream was so narrow that it did not permit going any distance from the mountains. All the gliders descended, and only the glider "Krasnaya Zvezda" remained untested since the designer and pilot of this glider S. P. Korolev was ill. Pilot Stepanchenok, head of the flight unit of the rally, took it upon himself to test the machine. He rose in the glider, "Krasnaya Zvezda," made a steep turn, and flew along the mountainslope. Soon /23
he gained an altitude of 300 m, after which, unexpectedly for the spectators, he began to dive steeply. A commotion broke out on the glider field since everyone had decided that a crash was imminent. But, 100 meters from the earth, the glider abruptly soared upward and made a right loop. Then followed a gain in altitude and a second and third loop. This was unprecedented and unheard of. For the first time in the world not one but three loops were performed on a glider in free flight. The pilots very highly evaluated this achievement for its true worth. The possibility was open for teaching student pilots acrobatics in gliders. It seemed that the key to understanding why the glider designer

*Report given on March 22, 1965 at the 73rd session of the Section for the History of Aviation and Astronautics of the Soviet National Union of Historians of Science and Technology.

increased the load on the wing of his gliders was found. But actually, this was far from so. The reason was uncovered many years later.

During the period from 1930 to 1935, S. P. Korolev constructed a number of gliders. The last glider, SK-9 (the same as the RP-318-1), was constructed by him in 1935. This was a two-seat cantilever monoplane. It performed long towed flights (Moscow-Crimea). The load per square meter of this glider was 25.9 kg.

Only with the appearance of the SK-9 glider was the thought of the glider's designer, which he had nurtured from 1929 and for which he had so carefully prepared, finally formulated. S. P. Korolev intended the SK-9 for installation of a rocket engine on it. For this purpose the load per square meter of wing was increased from glider to glider. This was an extremely bold idea, if we recall that in 1929 F. A. Tsander had just performed the calculation of his rocket engine, and at the end of 1930 began to test it. The glider designer had not only to foresee far ahead, but also had to be firmly convinced of the future of rocket technology.

The first half of the 1930s marked the beginning of bustling activity in the USSR in the area of rocket technology. Numerous units and groups consisting of young enthusiasts of rocket engineering were engaged in developing rocket engines. Following the first liquid-fuel jet engines, developed and manufactured in the USSR in 1930-1931 at the Gas Dynamic Laboratory (GDL) and later at GSJP, several dozens of rocket engines of different schemes and designs were constructed during the first half of the 1930s. True, these engines were far from perfect, some exploded, but they nevertheless worked, and of course, aroused the thought of their use in flying machines. One such attempt, carried out by a group of rocket enthusiasts, deserves particular attention since it gave rise to great progress in the development of rocket engineering.

At first, as a first experiment, it was proposed to install F. A. Tsander's rocket engine on B. I. Charanovskiy's "Flying Wing" RP-1 glider, which had been constructed in 1932. However, this work was not brought to completion, as a consequence of which the flight could not take place. The SK-9 glider proved to be the only one suitable at that time for installing the rocket engine. Even a place for the fuel tanks of the rocket engine was provided for on the glider. /24

At first it was proposed to mount the ORM-65 engine, developed by workers of the GDL, on the glider, but then it was decided to mount this engine on a winged rocket and another engine was manufactured for the glider. A year and a half was spent constructing the new engine. It was finished in 1939 and had the designation RDA-1-150 No. 1.

In view of the long time that had passed since the manufacture of the SK-9 glider, it was subjected to a thorough examination, its strength calculation was analyzed, and it was turned over for the expert advice of the Central Aerodynamic Institute. The detected defects of the glider were eliminated. Skis and a cowling for the rocket engine were additionally manufactured since these were completely absent.

Four test flights were carried out on the glider to check its flight data, and five ground tests of the rocket engine installed on the glider were made.

The equipment of the engine consisted of the rocket engine fastened on a special frame at the end of the fuselage, fuel lines passing inside the tail part of the fuselage; tanks installed behind the pilot's seat and at the place of the second seat; battery tanks fastened in the wing center section; electrical batteries fastened in the nose part of the fuselage; and instruments on the instrument panel to control the operation of the rocket engine. This installation caused a change in the ouside shape of the glider only in the rudder section. The equipped glider had all elements of an aircraft with a rocket engine. The data of the SK-9 glider and the RDA-1-150 engine were as follows:

		Glider	
		SK-9 (without engine)	RP-318-1 (with engine)
Wing span	m	17	17
Wing area	m^2	22	22
Load per square meter	kg	25.9	30.5
Length	m	7.28	7.28
Aspect ratio		13	13
Takeoff weight	kg	570	670
Weight of rocket installation	kg	-	100
Tank capacity	liter	-	60

Data of RDA-1-150 Engine /25

Thrust max.	kg	140
min.	kg	70
Consumption per second		
at maximum P	kg	0.75
at minimum P	kg	0.5
Pressure of fuel delivery		
max/min	atm	35/13

Testing of the rocket aircraft was given to one of the best glider pilots, Vladimir Pavlovich Fedorov. He was warned that this could be far from a safe flight. Fedorov, however, knowing all the possible dangers which could occur during the test, nevertheless without any doubts agreed to test it. Afterward he so loved the work of a test pilot that he devoted himself to this occupation entirely.

Before us lies a copy of the preliminary report on the test. Although it is printed on yellow, stiff wrapping paper, it fixes the day of the great achievement of the Soviet Union, the day February 28 1940, the first free flight of a glider with a rocket engine. Here is what the excerpts from record No. 6 of this report say:

FLIGHT MISSION

To tow glider 318 at H = 3000 behind an aircraft, to switch on the rocket engine. To hold the speed at or below 160 km/hour.

To keep the pressure in the combustion chamber of the rocket engine at 10 atm, which corresponds to 70 kg of thrust. To keep the engine operating until the fuel is used up. To fly with the engine operating along a straight line with a gain in altitude.

Glider 318 was filled with fuel components: 10 kg of kerosene, 40 kg of nitric acid.

Glider 318 was tested by test pilot Comrade Fedorov.

The crew of P-5 consisted of pilot Fikson, chief engineer of the rocket engine Comrade A. P. Pallo, and chief engineer of KB-29 Comrade A. Ya. Shcherbakov.

Before the flight the committee of the Technical Council of the People's Commissariat of the Aviation Industry granted the permission to fly with switching on of the rocket engine in the air, which was formulated by a written statement.

Glider 318 behind the P-5 towing aircraft took off at 1728 and gained an altitude of 2800 m in 31 min; glider 318 was disengaged by pilot Fedorov, after which he began to perform the mission.

Pilot Fedorov reported on the results of performing the mission as follows: /26

After disengaging the tow line for gliding, I established the direction of flight at a speed of 80 km, waiting for the P-5 aircraft observing me to approach, and began to switch on the rocket engine.

The rocket engine was switched on according to instructions. Starting of the rocket engine occurred normally. All control instruments worked well. The rocket engine was switched on at H = 2600 m.

A smooth, not abrupt noise was heard after switching on the engine.

Upon establishing a pressure of 12 atm in the combustion chamber, which corresponded to a delivery pressure in the fuel tanks of 22-24 atm, the rocket engine had a smooth operating regime which held until complete consumption of the fuel components.

Approximately 5-6 seconds after switching on the rocket engine the speed of the glider increased from 80 km to 140 km, after which I set a flight regime with a climb to 120 km and held it until the end of operation of the rocket engine. According to the readings of the variometer, the climb occurred at a rate of 3 m per second. During the 110-sec period of rocket operation there was a 300 m gain in altitude. When the fuel components were consumed, the fuel stopcocks were closed and the pressure removed, which occurred at H = 2900 m.

After switching on the rocket engine the acceleration occurred very smoothly. During the entire operation of the rocket engine I did not notice any effect on controllability of glider 318. The glider behaved normally, vibrations were not perceptible.

Acceleration from the operating rocket engine and its use for climbing left a very pleasant sensation in me, the pilot. After switching off the rocket engine, the descent occurred normally. During descent there was a number of deep spirals and tactical maneuvers at speeds from 100 to 165 km. The calculation and landing were normal.

The flight occurred under the following temperature conditions:

Ground temperature, 5.6°C
Temperature at H = 2900, 2°C
Ground wind, southwest at 5-7 m per minute

The crew observing from the P-5 airplane, Comrade Fikson, Comrade Shcherbakov, and Comrade Pallo, observed the following:

When pilot Fedorov switched on the rocket engine a small cloud of smoke from the ignition grain was noted, then the flame of the starting jets which left behind a trail in the form of a light-gray stream, after this the flame of the starting jets disappeared and a tongue of flame 1-1.5 m long appeared /28
from the operation of the rocket engine on the basic components.

The operation of the rocket engine on the basic components also left behind a light trail in the form of a light-gray stream, which rapidly scattered. Combustion of the fuel components in the rocket engine was complete.

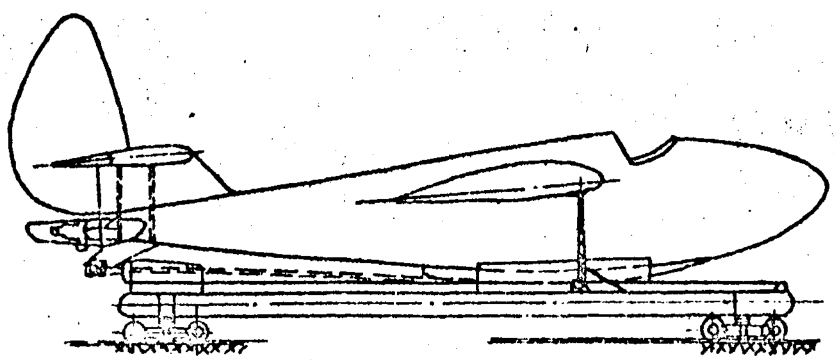

Diagram of rocket aircraft RP-318-1

Following the startup of the rocket engine we observed that glider 318 rapidly accelerated in horizontal flight and then began its climb. While endeavoring to maintain a constant distance with glider 318 to conduct observations, the aircraft P-5 dropped behind glider 318 despite a maximum increase of motor revolutions.

The operation of the rocket engine, which we observed, occurred smoothly from beginning to end. Starting up occurred normally. From the aircraft P-5 we could hear no noise from the rocket engine.

All those observing from the ground, including members of the Commission of the People's Commissariat of the Aviation Industry, saw at the initial instant of starting up of the rocket engine a cloud of smoke, after which the tongue of flame was even during the entire time of engine operation, which was accompanied by an even noise clearly audible on the ground. As the rocket engine ceased to operate, a small yellowish cloud, which quickly dissipated, was observed.

RESOLUTION OF THE COMMISSION

On the basis of discussing the rocket-engine flight and exchange of opinions with the technical commission of the People's Commissariat of the Aviation Industry, the latter decided to continue flight tests according to the established program.

The glider smoothly landed at a prescribed point. A group of future scientists and designers surrounded the pilot, each wanted to inquire personally how the flight was, how the glider and engine behaved. This was the first controlled flight with a liquid fuel rocket engine. It opened a new era.

Prior to this flight what was known abroad in this area? A glider flight was accomplished in 1928 in Germany by Stamer on a solid propellent engine, which gave momentum to the glider, after which the glider flew by inertia. These two flights are incomparable. In the USSR a rocket aircraft flew with a controlled engine which operated 110 seconds, whereas the longest duration of burning of Stamer's rocket did not exceed 30-40 seconds. Stamer's experiments ended with the glider burning.

In 1937 the Heinkel Company in Germany made the first flight tests of a liquid fuel rocket engine on the H-112 aircraft. Here the liquid-fuel rocket engine was installed in the tail of the aircraft as an additional engine to the main, piston engine. Consequently, this was not a free flight. Flight tests were terminated owing to the aircraft crashing during a forced landing. /29

During 1934-1940 flights tests of a liquid-fuel rocket engine designed by Dalmeyer were carried out in Germany on the He-111 aircraft. The operating time of the engine did not exceed 30 sec. The engine was supposed to be used as a starting booster.

In 1939 the Heinkel He-176 completed its first rectilinear flight in Germany lasting 50 sec with a Walter HWK R-1 liquid fuel rocket engine; however, work on this aircraft was later stopped.

The flight of S. P. Korolev's Soviet rocket aircraft RP-318-1 was exceptionally important for the development of Soviet rocket engines, for future ballistic rockets, and carrier rockets. Everyone saw with their own eyes that the time for the practical use of rocket engines was quite close. The flight in 1942 by pilot G. Ya. Bakhchivandzhi on the BI-1 aircraft confirmed this. Following him came the remarkable achievements of the Soviet people in space, which began with the launching of the world's first artificial satellite **designed and constructed under the supervision of S. P. Korolev.**

On February 28, 1940, 25 years ago, the modest first flight of the rocket aircraft RP-318-1 proved to be the spark which gave rise to the flame of great achievements of the Soviet people in space. We will always remember this, we will always remember the glider creator--S. P. Korolev.

N68-13577

ALL-UNION CONFERENCE ON THE USE OF JET AIRCRAFT IN MASTERING THE STRATOSPHERE*

Yu. V. Biryukov

ABSTRACT. The First All-Union Conference on Use of Rocket-propelled Flight Apparatus for Conquering the Stratosphere was held in Moscow, March 2-3, 1935. The introductory report was given by M. K. Tikhonravov; it was an analysis of the present state of rocket technology. S. P. Korolev reported on the progress being made in designing of rocket planes. V. P. Vetchinkin reported on rocket dynamics. Other reports covered gas and aerodynamics, wind tunnels, jet fuel, and flight medicine.

The conquest of unknown spaces was always and remains that part of human activity which especially attracts the attention of broad masses of people. /30
The first half of our century was a time when man conquered the air ocean, penetrating ever higher into its "depth," and the stratosphere was the main line of this attack. Particular attention was devoted to conquering the stratosphere in the 1930s, when each event of "storming the stratosphere" became an event in the public life of the country. One such event was the First All-Union Conference for the Use of Jet Aircraft in Mastering the Stratosphere, which was held by the Jet Research Institute and Stratosphere Committee of AviaVNITO a year after the First All-Union Conference for the Study of the Stratosphere, convoked by the USSR Academy of Sciences, was successfully held. The founder of astronautics, K. E. Tsiolkovskiy, was invited to this conference, and then was elected Honorary Chairman of the Presidium. Although the great scientist could not be present at the conference, he ardently welcomed and highly esteemed its work.

The First All-Union Conference for the Use of Jet Aircraft in Mastering the Stratosphere was held in Moscow at the Central House of the Red Army on March 2-3, 1935. In all, there were three sessions and 50 reports were heard. When setting out to briefly review these reports, it is necessary to note that, despite the survey character of these reports, not one of them was of a random, abstract nature, but backed up by a specific direction in the investigations that had been carried out and, what is especially important, all reporters supported the "establishment only on real things, on scientifically founded and not on fantastic prospects."**

M. K. Tikhonravov, engineer of RNII and the designer of the first Soviet liquid fuel wingless rockets, in his introductory report, "Prospects of the /31

*Report given on March 22, 1965 at the 73rd session of the Section for the History of Aviation and Astronautics of the Soviet National Union of Historians of Science and Technology.
**Tekhnika vozdushnogo flota, no. 7, p. 35, 1935.

Development of Rocket Technology and Conquest of the Stratosphere"* gave a detailed review of the state of rocket technology of that time and specifically examined the problem of the rapid development of stratosphere rockets.

The first part of the report even today can serve as a true specimen of scientific popularization of rocket technology. Arguing against the opinion extremely widespread in the popular literature at that time that "by means of a rocket engine it is possible to achieve colossal gains in almost all areas of technology and that it should replace all other less advantageous engines"**, the reporter indicated that despite the fact that "the appearance of a liquid fuel rocket engine is a factor of progress in modern technology, this engine can in no case replace a single one of the existing types of engines in the areas of use of which it will be less perfect and less advantageous.

The appearance of the rocket engine opens new means for travelling in those spaces of our world and the universe which are inaccessible at present to aircraft equipped with any other engine."***

Further, Tikhonravov scientifically demonstrated that the rocket engine is an engine of high speeds. And all attempts to use it in ground transportation are associated either with certain publicity purposes, or attributed to the inadequate scientific and technical knowledge of the inventors. The effective area of use of a rocket engine is "where it will give us an advantage over others, namely in stratosphere and extraatmosphere transportation."****

In passing, Tikhonravov dwelled on the prospects of the development of the jet engine. He said: "...we have at hand not only the theory of such an engine (developed by Prof. Stechkin) but also the practical proposals on the scheme of its construction (engineer Tsander, and others). We can hope that complete attention is not devoted to this engine on the part of the workers of our motor /32
industry...in the future the role of the jet engine in the development of stratosphere transportation will be most significant."*****

Evaluating the possibilities of a rocket for stratosphere exploration, the reporter noted that a rocket for altitudes above 30-40 km will be the main and only means of exploration, whereas indirect methods of investigation, actinometric, acoustic, and astronomic, are already supplementary to rocket exploration.

Of particular interest is the second part of the report. Here a method for the design and ballistic analysis of a rocket is presented for the first time for a simple case: vertical flight of a single-stage liquid-fuel rocket. Weight characteristics of individual elements of the rocket structure were presented, its weight equation was constructed, and graphs of rocket climb as a function of the ratio of masses, discharge velocity, and initial rocket mass are given.

*Tikhonravov, M. K.: Use of Rockets for Exploring the Stratosphere. Rocket Technology (Raketnaya tekhnika). Moscow-Leningrad, pp. 18-33, 1936.

**Ibid., p. 18.

***Ibid., p. 18.

****Ibid., p. 19.

*****Ibid., p. 20.

An analysis performed by the reporter showed that the level achieved by rocket technology in 1935 permits developing a stratosphere rocket of a simple design with a high-pressure air container with the following characteristics:

Initial mass 200 kg
Design mass 69 kg
Mass of useful load (instruments, parachute) 9 kg
Mass of fuel 122 kg
Exhaust velocity 2000 m/sec
Maximum height of rise 45 km

The design of such a rocket was examined.

Later, M. K. Tikhonravov dwelled in detail on the problem of increasing the maximum altitude and indicated what would result from an increase of the exhaust velocity and decrease in the relative weight of the structure and how these improvements of the rocket parameters could be achieved. It was indicated that in the near future an altitude of more than 500 km could be achieved by a single-stage rocket with the use of pump delivery, and even a greater altitude by means of sectional rockets. The reporter noted the value of the proposals by V. P. Vetchinkin, Yu. V. Kondratyuk, and F. A. Tsander directed toward the development of ideas of sectional rockets, and at the same time indicated the considerable complexity of the technical solution to the problem of developing such rockets.

It is necessary to point out the fundamental thesis of the report relating technology of 1935 with the achievements of today: "Exploration of the stratosphere is not the end purpose of the development of rocket engineering. This /33 is only a means to get firmly established, to prepare technically for man to rise at first into the upper layers of the atmosphere, then to go beyond it and find ways into space to other celestial bodies."*

Having touched upon problems of space flight, Tikhonravov discussed the prospects of using radiant energy, and primarily, solar energy as the prime mover of a space rocket. In passing it should be pointed out that at that time he had made a serious investigation of the use of radiant energy for space flight, in which a promising scheme of a nuclear-hydrogen engine operating on electrical energy produced by solar batteries was proposed for the first time, and design calculations of a rocket with such an engine for manned flight to the moon were first carried out. This investigation was published in 1936** and now it should be regarded as a true landmark in the development of Soviet astronautics.

In concluding his report Tikhonravov pointed out the considerable attention which is being devoted to rockets abroad and expressed the conviction that "in the development of rocket technology the USSR, a country where socialism is being

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*Ibid, p. 32.
*Tikhonravov, M. K.: Ways of Utilizing Solar Energy for Space Flight. Jet Propulsion (Reaktivnoye dvizheniya). No. 2, Moscow-Leningrad, pp. 109-140, 1936.

built, a country of new technology, should be and will be in the front."*

S. P. Korolev, engineer of RNII and leading designer of winged craft, gave a detailed report "A Winged Rocket for Manned Flight."** The contents of this report are today of great historical interest since it presents for the first time, on a scientific basis, the features and possible scheme of a winged piloted rocket (rocket aircraft), its design weight analysis, and analysis of its flight characteristics.

Having indicated the failure of numerous attempts to install a rocket engine on an ordinary aircraft, i.e., the mechanical transfer of rocket engineering to aviation, the reporter showed that the specific characteristics and the dynamics of rocket aircraft flight, its trajectory, and its class result in the similarity between a rocket aircraft and a propeller aircraft being very negligible despite features in common with an ordinary aircraft. The rocket aircraft will have the classical cantilever monoplane configuration, with a wing of thick /34
profile, centrally situated fuselage, with the tail assembly fastened to the end of the fuselage. The following external characteristics will be inherent to it: small span, small aspect ratio, and small size of the lifting surface. The fuselage will have an appreciable length and will be occupied mainly by the engine, tanks, devices powering the engine, etc. The wing will also be used for placement of various units of the engine, instruments, etc. As we see, in these words are anticipated the features of modern rocket aircraft (for example, the X-15).

It is interesting to dwell on the problems noted in the report which designers of rocket aircraft faced in 1935. Concerning these problems the reporter said that here "a powerful liquid fuel rocket engine occupies the main place. The realization of manned flight in a rocket aircraft depends directly on achievements in this area." Other urgent problems were: "a pressurized cabin: its considerable size, complexity of concluding any kind of control, and, mainly, its appreciable weight"***; protection of the pilot against the harmful effect of large g-forces during flight; the need for achieving good flight characteristics and appreciable increase of initial weight of the rocket, with which is related the enormous "difficulty of developing and operating such a vast high-altitude craft and the extraordinary difficulties of working with vast quantities of liquid gases,"**** required as fuel for it.

Today we can say with pride in Soviet technology that all these then seemingly extremely difficult problems have been successfully overcome and are now behind us.

Having examined the characteristics of a rocket aircraft and the problems related with its development, the reporter moved on to a design analysis of its flight and weight characteristics. The numerous graphs illustrating this part of the report, compiled on the basis of specific design investigations carried out at that time at RNII, are of considerable interest since they very com-

***Ibid., p. 36

****Ibid., p. 44.

*Tikhonravov, M. K.: Use of Rockets for Investigating the Stratosphere. Rocket Technology (Raketnaya tekhnika). Moscow-Leningrad, p. 33, 1936.

**Tekhnika vozdushnogo flota, No. 7, pp. 35-56, 1935.

pletely reflect the real level of achievements of rocket technology of that time. As an example, we can indicate the graphs of the dependence of the weight of single-chamber and multichamber liquid fuel rocket engines on thrust, weight of tanks, on fuel supply, weight of the pump unit, on fuel consumption and supply /35 pressure, maximum height of rise on ratio of masses, on initial thrust-weight ratio, etc.

On the basis of this weight analysis, data of a simple winged rocket were presented for manned flight into the stratosphere under conditions of its minimum weight. This weight of 2000 kg was distributed in the following manner:

pilot in spacesuit	- 5.5%
engine	- 2.5%
high-pressure container	- 10.0%
tanks	- 10.0%
structure	- 22.0%
fuel	- 50%

Such a rocket could rise to an altitude of 20 km at a specific impulse of 250 kg-sec/kg and thrust of 2000 kg.

In the case of using pump delivery of fuel, its supply could be increased to 60% of the initial weight of the rocket. Calculations of the flight characteristics of the winged rocket were carried out by V. P. Vetchinkin's method. The following trajectory proved to be optimal with respect to the flight altitude: the rocket is accelerated along the earth by solid propellent boost motors to a speed of 80 m/sec, takes off, and begins to climb at an angle of 60° on the motor proper, after using up all fuel the rocket changes into vertical flight by inertia and reaches a height of about 32 km, then the rocket noses over, picking up speed, after which it changes into a gliding flight, reaching a range of about 220 km at a total flight time of 18 min. The trajectory optimal in terms of range gives 280 km and the trajectory optimum with respect to speed gives 600-700 m/sec.

In conclusion, the report examined, first, different schemes of prospective aircraft: sectional and compound. It was pointed out in particular that at altitudes up to 30 km jet engines are of exceptional interest and value for the flight of rocket apparatus. Second, craft with rocket engines designed for flights of a purely experimental nature at low altitudes were examined.

The first attempt to develop such a craft was the work performed in 1932-1933 at GSJP with B. I. Cheranovskiy's glider RP-1 (BICh-II) on which was mounted F. A. Tsander's OR-2 engine. Then work was not carried out to completion because of imperfections of the engine. The report pointed out the need for developing a new rocket aircraft-laboratory on which "a study of the operation of various rocket units in air could be systematically carried out. On it it would be possible to set up the first experiments with a jet engine and an entire /36 series of other experiments, at first towing the craft to the necessary altitude. The ceiling of such a craft can reach 9-10 km."*

*Ibid, p. 56.

As is known, such a craft, the RP-318, was soon developed at RNII after the design and under the supervision of S. P. Korolev. True, owing to abnormalities associated with the situation of the cult of personality, the rocket aircraft was flight tested only in 1940.

The conclusion of the report is interesting in that it is extremely characteristic for the entire style of work of the reporter at RNII as a whole, and therefore we will present it in its entirety.

"The winged rocket is of great importance for super-high manned flight and for stratosphere exploration.

"The task of the future is to master the principles of rocket technology by persistent daily work, without superfluous ballyhoo and publicity which is so often inherent, unfortunately, even now to many works in this area, and to study first the strato- and ionosphere. The task of the entire community, the task of Aviavnito and Osoaviakhim is to gain every kind of assistance in this area and to properly formulate the topics on rocket engineering for lower organizations of society and individual inventors and to intelligently popularize the ideas of rocket flight."*

V. P. Vetchinkin, a professor at TsAGI, presented a major report on rocket dynamics.** He familiarized the audience with his works on the construction and solution of equations of the vertical motion of a rocket with a high speed in a medium with variable density and showed that a rocket must develop a velocity of 3000 m/sec for vertical flight through the earth's atmosphere. Then he thoroughly examined the flight dynamics of a winged rocket, the construction and solution of equations of motion, including with consideration of drag at supersonic velocities and determination of the optimal parameters of the flight path. Vetchinkin dwelled with particular details on gliding dynamics from very high altitudes with consideration of the change of air density, energy of the aircraft, and curvature of the earth.

In conclusion, the reporter elucidated the difficulties of achieving escape velocities on the basis of Tsiolkovskiy's works.

The morning session of March 3 opened with vigorous debates, which showed that /37
the reports were made on problems vitally important for the development of our rocket technology. Especially interesting were the addresses of engineer A. G. Kostikov who dwelled on problems of accomplishing pump fuel supply to the liquid fuel rocket engine and problems of investigating Tsander's forward and reverse cones, of engineer S. A. Pivovarov on the problem of developing an automatic gyro and radio control of rockets, and of engineer-inventor P. I. Shatilov on the advantages of his scheme of a liquid fuel rocket engine. It is interesting to note that in the discussions two different views appeared concerning the prospects of rocket technology. Thus, for example, it was stated in one of the reports that an unreal problem was formulated in the work of V. P. Vetchinkin since motion with very high speeds was examined, whereas engineer G. E.

*Ibid., p. 56.

**Information on the reports and speeches not published in the press are presented on the basis of communications of the periodical literature and notes of the conference taken by M. K. Tikhonravov and stored in his personal archive.

Langemak, conversely, noted that the report gave very modest figures which can create a pessimistic mood, whereas reality promises more optimistic prospects for rocket technology.

The agenda of the second day of the conference began with a report of the outstanding Soviet gas dynamicist F. I. Frankl', professor of TsAGI, in which he presented a brief history and principles of gas dynamics. The reporter dwelled more thoroughly on his graphic method of calculating supersonic flows with axial symmetry and its applications to finding the most advantageous shape of the rocket engine nozzle. It is interesting that in his report Frankl' elaborated the problem of aerodynamic heating of bodies during their motion at high speed, which at that time had still not been brought up technically.

The reporter V. I. Dudakov, engineer at RNII and leading Soviet specialist in rocket acceleration of aircraft, examined the theory of starting with the use of rocket boosters and told about a technique for accomplishing such a start which was developed and realized at GDL on RNII.

The second report of Prof. Frankl' examined, from the aerodynamic point of view, the possibilities of Tsander's proposed combined engines consisting of an engine-propeller unit and examined the possibility of creating a rocket propeller.

Of great interest were the reports of workers of RNII on the first supersonic wind tunnels. Engineer M. S. Kisenko gave a review of all high-speed tunnels of that time. There were only 8 such tunnels in the world, of which three were in the USSR: one at TsAGI, another at the Khar'kov Aviation Institute, and the third at RNII. The last tunnel was thoroughly described by the author of the design and supervisor of the works on its development, Yu. A. Pobedonostsev. This tunnel made it possible to obtain an open air flow with a diameter from 40 to /38
60 mm at an absolute flow rate up to 900 m/sec under normal conditions (i.e., at a static pressure in the stream of 760 mm Hg and air temperature in the stream of +15°C) and up to 1100 m/sec at a low stream pressure. The design and construction of the tunnel and the method of experimenting in it were reported.*

The evening session began with a survey report of one of the leading engineers of RNII, the author of a variety of the first Soviet liquid fuel rocket engines, "Fuel for Jet Engines and Requirements on Materials for Engines and Rockets." In the examination of fuels particular stress was laid on high-boiling components and, primarily, on nitrogen-containing oxidants: nitric acid, nitrogen tetroxide, and tetranitro-methane. Examined in detail was the problem of igniting the fuel, and specifically, igniting by means of pyrotechnic grain, which subsequently became widely used. Speaking about the requirements on structural and insulating materials for a liquid fuel rocket engine, the reporter demonstrated for the first time to a large audience the burnt, exploded, and fused parts of engines, which convincingly confirmed his presented data.

Processes of burning in a jet engine chamber were examined in the report of A. V. Zagulin, scientific associate of the Leningrad Physicochemical Institute.

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*Pobedonostsev, Yu. A. and M. S. Kisenko: High-Speed Wind Tunnels. Rocket Technology (Raketnaya tekhnika). No. 2, Moscow-Leningrad, pp. 143-203, 1936.

The reporter noted that all works on burning were heretofore carried out by two separate ways. The first way was empirical design of machines in which the burning process should occur, and attempts to influence this process by changing the design. The second way, also in essence empirical, was to act on the very mechanism of burning without changing the design mainly by introducing various chemical additions. Now it has become clear that a third way can lead to the development of the theoretical basis for an efficient organization and control of the burning process: a detailed study of burning processes with a comprehensive consideration of the most diverse factors: chemical, structural, hydrodynamic, etc.

Having divided the burning process in a rocket engine into three stages: chemical processes before ignition, the formation of a flame, and the motion of the flame, the reporter examined each of these stages from the point of view of the theory of burning and made a number of important conclusions concerning the significance of the rate of entrance of the fuel components into the combustion chamber, significance of the induction period, effect of vorticity and disper- /39
sion of the working mixture, unsteady operation of the motor during starting and the effect of introducing active additives to the fuel on its operation. The report of Zagulin was of great value because he, on one hand, showed that Soviet specialists in rocket engines are basically following the correct way from a scientific point of view in developing liquid fuel rocket engines, and, on the other hand, served as an impetus for setting up at RNII a number of purposeful scientific investigations in the area of managing burning processes in liquid fuel rocket engines. Here it should be noted that the associates of the Leningrad Physicochemical Institute not only helped workers of RNII get on the scientific pathway in the area of studying burning but also derived much that was useful for their own work from their contacts with the rocket specialists, since during those years processes of burning of pure fuel in a pure oxidant at high consumptions per second could be observed at RNII.

Biomedical problems were also examined at the conference. The report "Physiology of Manned Flight in a Rocket" was given by N. M. Dobrotvorskiy, chief of the laboratory of organization of flight duties at the Air Force Academy im. Zhukovskiy, a great enthusiast of this problem who has made a great contribution to the development of high-altitude and high-speed aviation medicine.

The work of the Jet Group under the military-scientific committee of the Central Council of Osoaviakhim was reported by its director I. A. Merkulov, and the work of the similar Leningrad Group was reported by engineer A. N. Shtern.

The reports made on the second day of the conference also evoked lively discussions. Particularly interesting was the speech of N. G. Chernyshev, engineer at RNII, who, arguing against the principal reporter on the problem of rocket fuels, stated that chemistry promises very great prospects with regard to rocket fuel, and dwelled in greater detail on the problem of using such promising components as ozone, silanes, and solutions of acetylene in acetone.

In conclusion the conference passed resolutions on all reports, which presented an expanded plan for the future works on the development of rocket technology and its application to conquering the stratosphere.

The First All-Union Conference on the use of jet aircraft for conquering the stratosphere was the world's first such forum of rocket engineers which discussed the most topical problems facing them and pointed out effective methods of solving these problems which had long impeded progress in the development of Soviet rocket engineering. Herein lies the great historical significance of the conference.

N68-13578

HISTORY OF DEVELOPMENT OF SOVIET SEAPLANE AVIATION*
(Period before the Second World War)

K. F. Kosourov

ABSTRACT. The report covers the development of the hydroplane in Russia and other countries before and after the Revolution.

Seaplane aviation arose in the first decade of the Twentieth Century, i.e., about 30 years after the development of the world's first aircraft. The progress which aviation made in the first stage of its development served as an impetus for attempting to use it at sea. The use of the water surface as a natural airfield vigorously expanded aviation prospects. The seaplane could prove to be useful where there were rivers, lakes, or sea coast. /40

The first experiments of taking off from the water in Russia were in 1911. One of the pioneers and initiators of this event was Yakov Modestovich Gakkel', who since 1910 had already had experience in flying a land aircraft of his own design. To him belongs the honor of developing the first Soviet seaplane.

Prior to 1912 seaplanes in all countries were exclusively float planes. It was not easy to reject the idea of using a landing carriage and fuselage. The replacement of wheels by floats had as its sole object the accomplishment of takeoff from the water surface. The floats were distinguished by imperfection in the shape of the outlines and, from the point of view of seaworthiness, left much to be desired. Seaplanes were capable of taking off only on a quiet water surface. Even slight waves were an obstacle to takeoff, the floats often did not endure the dynamic loads of the water and broke. As an example we can name Fabre's floats (1910). They somewhat resembled a wing in shape, were flat-bottomed, relatively broad, and rectangular in plan. Structurally they consisted of a wooden skeleton covered with waterproof fabric.

Frequent accidents and poor seaworthiness of the first seaplanes necessitated a search for new ways for developing better designs. To solve to some extent the problem of seaworthiness, designers, of course, thought about using the experience of hydroplane shipbuilding and transfer to the area of seaplane aviation. As a result the flying boat was born, the shape of the lines of the nose part of which and the presence of steps resembled a high-speed hydroplane-launch. The high centering of the seaplane and high situation of the thrust lines, the need for changing the trim during the takeoff run and setting of the tail assembly, the facility for easy takeoff from the water, and aerodynamic requirements, i.e., everything that essentially distinguishes a seaplane from /41

*Report given on October 30, 1963 at the session of the Leningrad Branch of the Section on the History of Aviation and Astronautics of the Soviet National Union of Historians of Science and Technology.

a hydroplane could not help but effect a substantial modification of the body of the latter. However, the process of this modification was far from simple.

The first flying boats appeared in France in 1912. They belong to the category of biplanes with a pusher propeller and were the prototype of flying boats which became widely used and were retained in aviation for more than a decade. The shape of the body lines and the ratio of the main linear dimensions were retained without substantial changes almost to the beginning of the Second World War.

The flying boat constructed in 1912 by the French designers Donne and Levec were not noted for its seaworthiness. It was too blunt-nosed and had a flat bottom in the nose section, which promoted during the takeoff run the development of a bow wave and severe splashing. The step with respect to the center of gravity was too far forward. These defects greatly hampered takeoff.

The well-known Russian designer Dmitriy Pavlovich Grigorovich was able to successfully solve, in 1913, the problem of a flying boat. His first flying boat M-1 weighing 880 kg was equipped with a 50-hp motor, and in later models M-3 and M-4 with a 100-hp motor, and developed a speed of 100 km/hr, high for that time. It is necessary to point out that in speed competitions organized by the French at St. Malo, the seaplanes of foreign firms scarcely reached a speed of 85-90 km/hr.

Resting on his own construction experience and having an exceptional design flair, Dmitriy Pavlovich soon developed the flying boat M-5, which as early as 1915 was in the service of our naval aviation and participated in military operations on the Baltic and Black Seas. The boat had a 100-hp engine, /42
a speed of 108 km/hr, ceiling of 4000 m, and duration of 5 hr. Many of our naval aviator graduates were taught on the M-5 seaplane.

The difficulties common to all aviation designers of that time were aggravated in the area of seaplane construction by the absence of developed methods of calculating the seaworthiness of a seaplane. The theory of hydroplaning still did not exist. Far from all means of ship theory could be used in seaplane construction owing to the specific characteristics of a seaplane. The experience in designing and operating high-speed launches, which did not have a very close hydrodynamic relation with seaplanes, was of little use. In spite of the difficulties, D. P. Grigorovich accepted the commission of the Naval Ministry to design and construct various types of seaplanes and proved to be capable of fulfilling it successfully. The seaplanes ordered by the Chief Naval Staff, were produced in series. D. P. Grigorovich's boat M-9 (1916) had such good seaworthiness and flight and tactical characteristics that the countries of the Entente obtained this seaplane from the Provisional Government of Russia.

From the historical point of view, D. P. Grigorovich's boat M-11 deserves particular attention, since it was not only the world's first naval fighter but also the world's first airplane with armor. The M-11 flying boat was armored in the nose section and at vital places.

In 1917 D. P. Grigorovich, together with M. M. Shishmarev and subsequently with Ye. I. Mayoranov, professor at the Red-Banner Order of Lenin Air Force Academy im. Prof. N. Ye. Zhukovskiy, constructed the world's first two-float torpedo plane for "GASN," which could carry an uncommon load for that time, a torpedo weighing 1 ton. In 1927, D. P. Grigorovich created a new machine "Explorer of the Open Sea" designated ROM-1 with an all-metal hull.

Design engineer V. B. Shavrov was the chairman of the light seaplane construction industry in the USSR. In 1929 he designed and built a light seaplane which was soon somewhat enlarged and batch produced in 1930. This miniature flying boat-amphibian with a 100-hp M-11 engine, called the Sh-2, is well known in aviation.

Several experimental seaplanes were created by K. A. Vigand and P. D. Samsonov, who in the 1920's, together with V. B. Shavrov, joined the staff of D. P. Grigorovich's design department. /43

Soviet seaplane technology gained considerable experience in mounting land aircraft on floats. As an example we can point out the heavy bomber TB-1 designed by Academician A. N. Tupolev. This aircraft, named the "Country of the Soviets" piloted by Shestakov and Bolotov made the well-known round trip flight from Moscow to New York in 1929.

The name of A. N. Tupolev and his design team is associated with the construction of heavy seaplanes. Thus, in 1930 was constructed the two-motor flying boat ANT-8 which had, primarily, an experimental value. In 1934 two seaplanes were developed: MTB-1 and ANT-22. The first of these was a three-place monoplane with AM-34 engines mounted in three nacelles extended on props under the wing. The aircraft was intended for long operations over the sea and had, for that time, good flight characteristics and seaworthiness. The second, the two-hull seaplane ANT-22, had six AM-34 engines mounted above the wing in three tandem units. This aircraft could carry a bomb load of up to 6000 kg and had powerful armament. A world record for altitude with a load of 13 tons was set on the ANT-22 in 1936.

In 1937 appeared the amphibian ANT-44 which was a monoplane with four AM-85 engines situated in the wing. The retractable landing carriage enabled the machine to use the land and sea as an airfield. The ANT-44 aircraft was a heavy bomber and long-range reconnaissance aircraft. It was successfully used in military operations during the Second World War. The high flight and tactical characteristics made it possible to set six records on the ANT-44.

Engineer I. V. Chetverikov developed and built new types of seaplanes. His seaplane for a submarine deserves attention.

About 30 years ago the navies of some countries raised the problem of the possibility of equipping submarines with aircraft. If a seaplane could be selected from the existing type of machines for a cruiser or battleship, then the extreme limitation in the size of submarine hangar would require the development of a specially designed aircraft. The problem of such an aircraft was successfully solved by I. V. Chetverikov, and his seaplane was exhibited at the International Exhibit in Milan in 1936. The seaplane had a collapsible engine truss, folding wings, cantilever parts of the horizontal tail surfaces and props of the wing float. Its flying weight was 800 kg. /44

We need point out I. V. Chetverikov's flying boat ARK-3 which was designed for servicing Arctic regions. Two world records for altitude while flying with a load were set on this machine.

We owe the appearance of many successful types of seaplanes to the fruitful activity of G. M. Beriyev. His flying boat MRB-2 with an AM-34 engine gained great popularity in naval aviation. Thanks to its high performance, this boat remained in the navy for a long time. G. M. Beriyev also developed naval reconnaissance aircraft and ship-borne aircraft.

From the first flying boat of D. P. Grigorovich to the heavy multi-engine air cruiser of A. N. Tupolev -- this is the historical path of development of Soviet seaplanes.

The start of the development of theoretical problems of the hydromechanics of seaplanes dates to the middle of the 1920's. The first theoretical solution to the problem of planing of a flat or slightly curved plate moving at a small angle of attack in a plane-parallel flow of an ideal fluid was obtained in the USSR by active member of the Ukranian SSR Academy of Sciences G. Ye. Pavlenko. Three years later Academician G. Ye. Pavlenko, proceeding from other physical concepts, gave an approximate theory of planing of a body having a finite width.*

In this last theory the development of dynamic pressure on the bottom is regarded as a consequence of the continuous overcoming of the inertia of the water masses, which, as the body moves, is displaced downward and to the side at a rate larger, the greater the speed of the body and the greater its angle-of-attack. This theory enabled G. Ye. Pavlenko to solve the problem of the rebound of a body from the free surface of a liquid.**

The theoretical works of Academician L. I. Sedov occupy a prominent place. /45
His numerous published works are devoted to problems of hydrodynamics. Of considerable interest are his works on the theory of the impact of a solid on water and on the theory of planing. Such works, for example, of L. I. Sedov as the "Theory of Unsteady Planing and Motion of a Wing with Trailing Vortices"*** and "The Plane Problem on Gliding Over the Surface of a Heavy Liquid"**** are fundamental works which affirm the leading role of the Soviet school of hydromechanics in this area of scientific knowledge.

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*Pavlenko, G. Ye.: Principles of Planing Theory. Proceedings of the Research Aero-Institute GVF (Trudy Nauchno-issledovatel'skogo Aero-Instituta GVF). Article 20, Leningrad, 1932.

**Pavlenko, G. Ye.: Phenomena of Rebound on the Water Surface, Morskoy sbornik, No. 1, 1932.

***Trudy TsAGI No. 252, 1936.

****Proceedings of the Conference of the Theory of Wave Resistance (Trudy konferentsii po teorii volnovogo soprotivleniya). Izd. TsAGI. Moscow, 1937.

The world's first problem on the theory of the impact of a solid against a liquid was solved by Professor N. Ye. Zhukovskiy in 1883. Further investigations of the phenomenon of impact were renewed only after almost 50 years and were brought about by the requirements of seaplane construction. Independently of the works carried out in the USA by Thompson, N. N. Podsevalov on the initiative and assignment of TsAGI carried out tests on the Black Sea and in 1931 published a report on an investigation of water pressure on the bottom of seaplanes. Experimental works were combined with theoretical investigations. Soon a number of theoretical works on impact theory appeared in the Soviet literature. Their authors were Academicians M. V. Keldysh, M. A. Lavrent'yev, and L. I. Sedov, as well as other researchers, mainly workers at TsAGI who substantially broadened this region of hydrodynamics.

In a brief outline it is not possible to enumerate or evaluate all, even basic works, which belong to the pens of our scientists.

All these works determine the major contribution of Soviet science to seaplane aviation and hydrodynamics.

We can only state that Soviet scientists have occupied a leading place in all the principal sectors of seaplane science.

CHRONICLE AND INFORMATION

AT THE SECTION OF THE HISTORY OF AVIATION AND ASTRONAUTICS

Twelve sessions of the Section of the History of Aviation and Astronautics, at which 19 reports and communications were given, was held in Moscow between October 26, 1964 and December 6, 1965. /46

The 67th session of the section held on October 26, 1964 was devoted to an examination of the problem of compiling a chronicle of astronautics (the report of I. Ye. Mosolov) and to analysis of G. Obert's suggestion (1929) of creating "electrical" spacecraft (the communication of V. I. Belolipetskiy).

The section examined the work of I. Ye. Mosolov on compiling a chronicle of astronautics and recommended its continuation; at the same time, the section passed a resolution to begin work on compiling a scientific and technical chronicle of astronautics reflecting the development of science and technology in space research.

Having discussed V. I. Belolipetskiy's communication on the little-known proposal of G. Obert in 1929, which played an essential role in the development of electric rocket engines, the section recommended translating this material into Russian and printing it in the publications of the section with necessary commentaries.

The 68th session of the section, held on November 10, 1964 was devoted to the 75th Birthday Anniversary of Academician B. N. Yru'yev. Academician M. D. Millionshikov, Vice-president of AN SSSR gave the opening address speaking on the life and creative pathway of B. N. Yur'yev. Friends and pupils of B. N. Yur'yev told about his scientific, pedagogical, and social activity. A detailed report on this session of the section is published in "Problems of the History of Science and Technology" (Moscow, No. 20, 1966).

On November 30, 1964, at the 69th session of the section, Prof. I. I. Anureyev, Doctor of Military Sciences, Major General of ITS, gave a report on the trends in the development of aircraft as strategic weapons.

Noteworthy dates in the history of aviation and astronautics in 1965 were examined and confirmed at this session. /47

The 70th session of the section, devoted to the display of matters pertaining to the history of aviation and astronautics in Moscow and Leningrad Museums, was held on December 25, 1964.

N. N. Femenkevich, a scientific coworker of the Museum familiarized the audience with the research works carried out at the M. V. Frunze Central House of Aviation and Astronautics.

T. L. Volkoviskaya, Director of the Department of Astronautics of the Polytechnic Museum told about the exhibits on astronautics at the Polytechnic Museum.

I. Ya. Shatoba, Deputy Chairman of the Section of the History of Aviation and Astronautics of the Leningrad Branch of the Soviet National Union of Historians of Science and Technology, gave a report on the organization of a "park of cosmonauts" with a pavilion of the history of aviation and astronautics in Leningrad.

Measures for creating in Moscow a Central State Museum of the History of Aviation and Astronautics and an archive for it was supported at the session of the section.

On January 28, 1965, at the 71st session of the section, results of scientific investigations into various problems of the history of space research were heard.

R. G. Bazurin spoke about space research and certain problems of developing modern science. V. I. Belolipetskiy spoke about problems of the development of the mechanics of small-thrust space flight (prior to the 1930s). I. N. Bubnov gave a report on problems of using ballistic rockets in the development of carrier rockets for space objects in the USA. G. V. Skvortsov reported on the development of liquid fuel rocket engines in the USA in 1954-1958.

All reports given at this session were published in a collection of reports for the scientific conference of graduate students and young scientific coworkers of the Institute of the History of Science and Technology AN SSSR (Moscow, VINITI, 1965).

At the 72nd session of the section on March 1, 1965, A. P. Smolin gave a scientific and technical review of foreign literature on problems of the history of aviation, rocket technology, and astronautics. K. I. Trunov /48
discussed V. K. Fedorov's rocket aircraft.

The 73rd session of the section on March 22, 1965 was devoted to the 140th Birthday Anniversary of A. F. Mozhaiskiy; Candidate of Technical Sciences, V. B. Shavrov reported on the scientific and technical creativity of the inventor.

Yu. V. Biryukov gave a survey of reports of the First All-Union Conference on the use of rocket craft for investigating the stratosphere, which was held in Moscow in 1935.

On April 19, 1965 the 74th session of the section was devoted to the role of V. I. Lenin in establishing and developing Soviet aviation science and technology, at which Hero of the Soviet Union, Candidate of Military Sciences, Colonel L. M. Shishov gave a report.

A. T. Skripkin, director of the Kaluga State Museum of K. E. Tsiolkovskiy, told about the course of construction of a new museum building and the state of works on preparing new exhibits and displays.

The 75th session of the section, held on May 19, 1965, was devoted to the 60th Birthday Anniversary of A. A. Shternfel'd. Leading scientists of the Soviet Union gave speeches at the session, and greetings from individuals and members of various organizations and cities of the Soviet Union and other countries were publicly announced. The question of awarding A. A. Shternfel'd the honorary rank of Doctor of Technical Sciences and the title of Honored Scientist and Technologist was discussed.

The 76th session of the section was held on October 18, 1965. The "Outlines of the History of Technology in the USSR," prepared by a team of authors under the supervision of general aviation designer Academician A. N. Tupolev, was discussed.

On November 15, 1965 the 77th session of the section was held. V. P. Razzhivin reported on the development of dirigible construction abroad. Representatives of the Leningrad Community Design Department of Aeronautics (chief of the department, A. N. Dmitriyev and Candidate of Military Sciences N. A. Brusentsov) gave brief reports on the technical and economic grounds for dirigible construction in the USSR. Prof. A. G. Vorob'yev (Leningrad) discussed the prospects of development of dirigible construction.

At the 78th session of the section, December 6, 1965, V. I. Belolipetskiy reported on the initial period of development of the mechanics of small-thrust space flight. The reporter told about the development of scientific and technical ideas leading to the logical construction of so-called electric rocket engine systems and the formation of a new branch of science, mechanics of small-thrust space flight. A. A. Kosmodem"yanskiy, Doctor of Physical /49
and Mathematical Sciences, Prof. I. A. Merkulov, and others, participated in the discussions, they supported and approved the conduction of further investigations in this area.

Memorial dates in the history of aviation and astronautics for 1966 were were examined and approved at the session.

V. N. Sokol'skiy, Candidate of Technical Sciences and a member of the International Committee on the History of Rocket Technology and Astronautics of the International Academy of Astronautics, discussed a meeting of this committee held in Athens during the 16th International Astronautical Congress (September 12-18, 1965). He reported on international scientific relations of Soviet historians of aviation and astronautics.

V. I. Belolipetskiy

The Leningrad Branch of the Section of the History of Aviation and Astronautics entered the 8th year of its existence in February 1966. On January 1, 1966 the section had 80 members, including 8 professors, 20 science candidates, and 3 lecturers. Of the remaining members 90% have very specialized aeronautical education.

At present the work of the section is directed by a department staffed by: P. P. Kvade (Chairman), I. Ya. Shatoba, F. G. Popov, V. L. Korvin, I. I. Smaga, I. F. Fanichkin, and V. S. Mitin.

In 1965 eight sessions were held at which 12 reports and communications were given. On January 26, 1965 Candidate of Technical Sciences, G. N. Kopylov's report "Historical Development of the Theory of Propeller Aerodynamics" was presented. At the same session G. T. Chernenko's "The Value of the Journal 'Balloonist' in the Development of Soviet Aviation" was read. It concerned the 85th anniversary of the publication of the first issue of ~~the~~ Journal "Balloonist."

Candidate of Technical Sciences, A. A. Kudinov's "Historical Development of Aircraft Designs" was heard on March 26. A short talk by V. L. Korvin on the "140th Birthday Anniversary of A. F. Mozhayskiy" was given.

The report of Candidate of Technical Sciences V. G. Shakhverdov "Modern Aviation Engines" was presented on April 23, a scientific film on aviation engines was shown at the same time. At this session were heard the communications of I. F. Fanichkin and K. D. Il'inskiy on meetings with V. I. Lenin, in connection with his 95th anniversary. K. D. Il'inskiy reported on V. I. Lenin's speech to workers of the aviation plant at N. Village at Villa Rode, and I. F. Fanichkin on a meeting at the Mendel'son Plant in Moscow on August 30, 1918. /50

On May 6, 1965 a celebration session of the section where the enlistment of the aviation community of Leningrad was organized in the large conference hall of the Leningrad Branch of the Academy of Sciences SSSR in connection with the 20th Anniversary of the victory over Fascist Germany. The chief marshall of aviation, twice Hero of the Soviet Union A. A. Novikov gave the report "Soviet Aviation in the Second World War" at the celebration assembly.

The report of Candidate of Technical Sciences V. B. Shavrov "Aircraft Designed by P. O. Sukhiy (in connection with the 70th anniversary of P. O. Sukhiy)" was given on May 21, 1965. This report was richly illustrated with photographs, designs, etc. It caused numerous questions on the part of the members of the section and lively interest of the audience.

The report of Doctor of Medical Sciences Sergeyev on the topic "Urgent Problems of Aviation Medicine" was presented on October 8, 1965. The report was made in a historical connection, and the development of aviation medicine from the end of the 19th century to our day was shown. The peculiarities of aviation medicine and its value for space medicine were clearly emphasized.

I. Ya. Shatoba's communication "Thirty Years Since the Death of K. E. Tsiolkovskiy" was presented at this session.

The report of engineer, deputy chairman of the Community Design Department of Aeronautics (OKBV), N. A. Brusentsev on the topic "Prospects of Dirigibles in the Age of Jet Aviation and Astronautics" was presented on October 29, 1965.

The report of Candidate of Technical Sciences A. G. Bedunkovich "Transport Aviation at a New Stage" was presented on December 26, 1965. On the basis of its content this report could be called: "Historical development of airdrome-free aviation." The report of Comrade Bedunkovich was well illustrated with photographs and diagrams, and evoked many questions.

Along with reports and communications, the members of the section, in 1965, prepared manuscripts on the following topics:

S. M. Yakovlav: "Historico-Biographic Outlines on the Life and Activity of V. A. Slesarev."

N. S. Trukhnanov: V. V. Kuznetsov, "Outstanding Russian Balloonist, Meterologist, and Aerologist." /51

M. N. Prashchenok: "Historico-Biographic Outline on the Life and Activity of Ya. M. Gakkel'."

K. N. Zatonskiy: "Military Use of Bomber Aviation for Solving Strategic, Military Problems of the First and Second World Wars."

Many members of the section are working on personal recollections and biographical outlines of outstanding personalities in aviation.

I. Ya. Shatoba

At the Ukraine Branch of the Section of the History of Aviation and Astronautics there were 17 sessions between January 1964 and October 1965, at which the following reports and communications were heard and discussed:

Goryainov, P. V.: "Radar in the Service of the Air Force."

Yefremov, K. V.: "Participation of the Third Aviation Fleet in the Revolutionary Events of 1917 in Kiev" (personal recollections).

Karatsuba, S. I.: "Aircraft of the Kiev Aviation Designer A. D. Karpeka." (The sister of Karpeka, Ol'ga Danilova, was present at the session and gave a speech).

Kochegura, M. A.: "VTOL Aircraft."

Kochegura, M. A.: "80th Birthday Anniversary of Scientist V. A. Slesarev."

Kochegura, M. A.: "Supersonic Transport Aircraft."

Kochegura, M. A. and Ye. V. Koroleva: "75th Birthday Anniversary of the Renown Russian Aviation Designer I. I. Sikorskiy."

Kochegura, M. A. and S. A. Sobolev: "80th Anniversary of the Tests of A. F. Mozhayskiy's Airplane."

Koroleva, Ye. V.: "Information on the Second Plenum of the Soviet National Committee of Historians of Science and Technology held on May 25-28, 1965 at Moscow."

Kropivnitskiy, L. P.: "Aviation Workshops in the Village of Chervonyy."

Laponogov, I. S.: "60th Birthday Anniversary of Valeriy Chkalov."

Laponogov, I. S.: "First Kiev Airfield."

Laponogov, I. S.: "50th Anniversary of P. N. Nesterov's Air Ram." (The daughter of Nesterov, Margarita Petrovna, was present at the session and gave a speech.)

Dyakhovetskiy, M. B.: "The Il'ich Squadron." /52

Sobolev, S. A.: "140th Birthday Anniversary of A. F. Mozhayskiy, the Creator of the First Russian Airplane."

Sobolev, S. A.: "Mozhayskiy and Mendeleyev."

Sofronov, N. I.: "On the Activity of the Oldest Aviation Designer of the Ukraine, S. V. Grizodubov" (in commemoration of his 80th birthday).

Tret'yakov, N. S.: "History and Progress of Aviation."

Tret'yakov, N. S.: "Certain Features in the Development of Aviation in Recent Years."

Kheyfets, L. S.: "Lenin and Aviation."

Shevchenko-Bolsunovskiy, N. S.: "Aviation in the Early Period of the Second World War."

On February 26 the section together with the Kiev Institute of Civil Aviation and the Administration of Civil Aviation held a jubilee session devoted to the memory of the Ukrainian aircraft designer Konstantin Alekseyevich Kalinin in connection with his 75th birthday. A pupil of K. A. Kalinin, Hero of the Soviet Union, engineer-pilot, A. N. Gratsianskiy gave the opening address. Pupils and comrades of the designer presented their recollections.

On the initiative of section member, Mikhail Osipovich Kovan' the Khar'kov community honored its 80-year-old fellow citizen, designer S. V. Grizodbuv on Air Force Day in 1964. He was awarded the Diploma of the Presidium of the Supreme Council of the UkrSSR.

Khar'kov also marked the 130th anniversary of the first balloonist of the Ukraine, M. T. Lavrent'yev. The city executive committee passed a resolution to establish a memorial plaque in honor of M. T. Lavrent'yev in Khar'kov.

Based on the scenario described by Kovan', the Khar'kov television studio prepared and showed viewers the performance of balloonist M. T. Lavrent'yev.

M. O. Kovan' spent considerable effort on the organization of a section on the history of aeronautics and aviation of local lore at the Khar'kov Museum. The exhibit in this section shows a model of S. V. Grizodubov's first airplane which the designer made by hand.

In recent years the section has increased its work on propagandizing the history of aviation. For this purpose Comrades Kochegura, Lyakhovetskiy, Laponogov, Shevchenko-Bolsunovskiy, and especially Sobolev and Kovan' have pre- /53 sented reports and held discussions at enterprises and organizations. Sobolev presented the report "From Mozhayskiy to Gagarin" at enterprises. In 1964, Kovan', as a nonstaff lecturer at the planetaritum, went to the collective farms of the Khar'kov region where he gave 47 reports on balloonist M. T. Lavrent'yev, and in the same year he gave 26 lecturers on "From the Balloon to Space Flight" at collective farms of the Galakleyevskiy region.

Members of the section have presented articles for the local, republic, and union press. For example, the newspaper "Vechirniy Kiiv" published:

Lapogonov, I. S.: "The Aerodrome that Went Down in History." August 12, 1963.

"Fearless Falcon." December 16, 1964.

"Museum of Aviation History." January 26, 1965.

Lyakhovetskiy, M. B.: "First Time in Service." September 26, 1963.

"First Regulars." May 25, 1964.

"Powerful Wings." April 18, 1964.

"Commander of the Antheum." August 13, 1965.

The newspaper "Sotsialistichna kharkivshchina" printed three articles by M. O. Kovan': On Grizodubov, Utochkin, and on Lectures at Collective Farms.

The journal "Kryl'ya rodiny" contained an article by I. S. Lapogonov "Veteran of Two Wars" concerning the old pilot T. S. Shelukhin (No. 7, 1965).

The L'vov journal "Zhovten'" printed V. A. Zamlinskiy's outline "50 Years Before the Start" (about F. R. Geshvend) (Zhovten', No. 4, 1965).

The newspaper "Aviator" of the Kiev Institute of Civil Aviation has become a permanent tribune on aviation history for members of the section. Not only hundreds of students and teachers read it, but the newspaper is also distributed to libraries of civil aviation units of the Soviet Union. The newspaper "Aviator" printed the following articles:

Kochegura, M. A.: "A Falsification from the History of Aeronautics" (No. 7, 1964).

Kratsianskiy, A. N.: "Talented Aircraft Designer" (No. 7, 1964) (about K. A. Kalinin).

Kheyfets, L. S.: "Pages of History." (From the history of the Kiev Aviation Institute) (Nos. 4, 8, 9, 12, 1965).

Sobolev, S. A.: "Mozhayskiy in the Ukraine" (No. 10, 1965).

Karatsuba, S. I.: "At the Dawn of Soviet Gliding" (No. 13, 1965).

Koroleva, Ye. V.: "First Flights" -- Chapter from the manuscript on M. N. Yefimov. (Nos. 19, 21, 22, 24, 1965). /54

Laponogov, I. S.: "Kiev Airdromes." (Nos. 29, 30, 1965) and others.

The journal "Narisi z Istorii tekhniki i trirodoznavstva" of the Ukraine Branch of the Soviet National Union of Historians of Science and Technology has regularly published, beginning with the third issue, articles from aviation history:

Issue 3. Lyakhovetskiy, M. B.: "Talented Ukrainian Craftsmen" (about I. S. Tereverko).

Issue 4. "80th Anniversary of Honored Pilot of the USSR B. I. Rossinskiy -- His Memoirs." 1964.

Dobrov, G. M.: "Documents from the History of Soviet Aviation."

Koroleva, Ye. V.: "New Material on the Life and Activity of the Russian Pilot M. N. Yefimov."

Denisenko, V. I.: "The Airplane 'Chur' Among the First."

Kochegura, M. A.: "On the Work of the Section of the History of Aviation and Astronautics."

Issue 5. Karatsuba, S. I.: "Gliders of the Kiev Polytechnic Institute." 1965.

At present the section is vigorously working on preparing the manuscript "Development of Aviation in the Ukraine." The materials submitted to the editorial board by authors are being examined and discussed at the section.

Furthermore, the section is solving problems of establishing an obelisk to P. N. Nesterov and the organization of an aviation museum in Kiev.

Ye. V. Koroleva

CONFERENCE OF HISTORIANS OF ASTRONAUTICS

The routine session of the International Committee on the History of Rocket Technology and Astronautics was held in Athens in September 1965. This committee, created in 1963 within the frameworks of the International Academy of Astronautics, has set out to coordinate and unify the efforts of scientists studying the history of these fields of knowledge.

Its staff is presently made up by representatives of eight countries: A. Haily and L. Shepard (England), T. Tabanera (Argentina), V. Sokol'skiy (USSR), /55 F. Malin and E. Emme (USA), S. Dolfus (France), I. Zenger-Bredt (West Germany), R. Pecek (Czechoslovakia), W. Von Euler (Sweden). The president of the International Academy of Astronautics, K. Draper and assistant director of the American National Museum of Aeronautics and Astronautics, F. Durant also participated in the work of the Athens session of the committee.

At the first meeting the committee discussed problems of the goals and tasks of historical research in the area of rocket technology and astronautics and the structure and program of work of the committee, and conducted a preliminary discussion of the problem of division into periods and passed a number of recommendations onto the president of the Academy.

After an exchange of opinions, the members of the committee concluded that at present, of greatest interest for the International Academy of Astronautics and for a broad scientific community are investigations in such areas as:

a) history of rocket technology
b) history of astronautics
c) history of space research
d) history of equipment for controlling space vehicles
e) history of means of communication in space
f) history of bioastronautics

It was also decided to institute an annual Th. Von Karman Prize (first president of the International Academy of Astronautics) for best work in the history of rocket technology and astronautics.

Because at present national committees uniting historians of rocket technology exist only in two countries, in the USSR (Chairman of the committee A. A. Blagonravov, deputy chairman V. N. Sokol'skiy) and in the USA (Chairman E. M. Emme, assistant chairman F. Durant), the committee resolved to place before the International Astronautical Federation the problem of creating national historical committees in all countries belonging to the Federation.

The second meeting of the committee began with informational reports of members of the committee on research into the history of rocket technology and astronautics carried out in countries represented by them. As was already noted above, in most countries historians of aviation and astronautics have so far /56 not been unified, and work largely independently of one another.

In this connection the members of the committee showed considerable interest in the problem of organizing research into the history of rocket technology and astronautics in the USSR and USA. Without dwelling on the work of the section of the History of Aviation and Astronautics of the Soviet National Union of Historians of Science and Technology (which has been repeatedly elucidated in our historico-scientific publications), we will present certain information on the organization of research into the history of these areas in the USA.

In the USA the first professional organization interested in the history of astronautics was the National Space Club which instituted, in 1959, the annual Goddard competition for the best work on the history of rocket technology and astronautics in order to stimulate the development of this area of knowledge in the USA. In 1962 the American Association for Scientific Progress and the Society of Technological Historians held a joint conference devoted to the history of rocket technology in the USA, in which, along with technological historians, participated G. E. Pendrey, W. R. Dornberger, J. P. Hagen, etc. In 1964 a Historical Committee was created, also under the American Institute of Aeronautics and Astronautics. Furthermore, individual research institutes and universities devote considerable attention to the development of the history of rocket technology and astronautics. It suffices to say that at a number of American universities a special course is given on the history of space flight. The Smithsonian Institute in Washington performs considerable research work in the area of the history of astronautics. Finally, quite recently it was deemed necessary to create a Historical Committee under the National Aeronautics and Space Administration (NASA).

Further, the committee discussed the problem of exchanging publications and information on works carried out in different countries and examining the plan of conferences and symposia in future years. It was resolved to hold, in 1967, an International Symposium on the topic "The Role of Pioneers of Rocket Technology in the Development of Astronautics."

The past session of the committee showed that in recent years interest in problems of the history of rocket technology and astronautics has grown appreciably in many countries. This challenges researchers working in this area with new, considerably higher requirements.

REVIEWS AND BIBLIOGRAPHY

A. M. IZAKSON. SOVIET HELICOPTER CONSTRUCTION. Izd-vo Mashinostroyeniye. Moscow, 1965.

Today, when helicopters have gained general recognition and have become a part of life, the appearance of a serious book devoted to the history of helicopter construction must be acknowledged as very timely and welcomed in every possible way. It is quite natural that Aleksandr Mikhaylovich Izakson, the elder figure in Soviet helicopter construction, should turn to this difficult topic. /57

Unlike his earlier literary works in this area* devoted mainly to foreign helicopter construction, the new book is a history of Soviet helicopter construction.

The book gives a thorough description of all works in the area of helicopters carried out in Russia from the time of M. V. Lomonosov until the October Revolution in 1917, gives a condensed version of all scientific works on propellers and helicopters by N. Ye. Zhukovskiy, and, finally, elucidates with exhaustive thoroughness the works of B. N. Yur'yev, a leading figure in Soviet helicopter construction.

The bulk of the book is devoted to works on helicopters in the Soviet Union. The periods between 1925 and 1937, the periods of the birth of Soviet helicopter construction, development of the first Soviet helicopters, and the first major progress in solving this problem, is elucidated quite thoroughly.

Most of those now working in various areas of Soviet helicopter construction have been engaged in this work during the past decade. For the most part these are young people.

These workers know little about the history and birth of Soviet helicopter construction, have vague ideas about the first Soviet helicopters, about autogiro construction, about the mutual influence of these two related branches of aviation. /58

For them this section of the book will be very useful and interesting since it is written with painstaking completeness, clarity, and with great fervor. And it could not be otherwise since the author of the book A. M. Izakson was an active participant of work on helicopters of that period, having headed for many years in the USSR, the design and research organization on helicopters and autogiros which brought together enthusiasts, talented people from among young engineers, and party members since 1917-1920, who passed through the harsh school of the Civil War, and the best representatives of nonparty specialists of the older generation.

Having undertaken the task of encompassing an appreciable period of time and of bringing the account up-to-date, the author of the book should have inevitably encountered a number of specific difficulties, since works of the recent past and contemporary work sometimes are difficult to objectively evaluate completely and sufficiently.

A. M. Izakson coped well with these difficulties, knowing how to evaluate quite objectively the quality and value of a number of constructed craft, the activity of design organizations, and the role of numerous workers in helicopter construction.

*Izakson, A. M.: Helicopters (Gelikoptery), Izd. GNTI, 1931 and Izakson, A. M.: Helicopters (Gelikoptery), Izd. Oborongiza, 1947.

Along with a detailed elucidation of the history of Soviet helicopter construction, the book gives an abbreviated review of the state of foreign helicopter construction at each historical stage. This is quite regular and proper since it gives the reader the opportunity to get a broader idea about the comparative level of world and Soviet helicopter construction.

People advance technology. It is natural that in a work on the history of the development of a particular branch of technology, the activity of people, the creators of this technology, should be sufficiently reflected and an evaluation of their constructive role at decisive stages be given.

A. M. Izakson quite scrupulously notes in his book the large number of participants who worked on the development of helicopters and autogiros, without limiting himself to mentioning only the main designers or principal directors, but naming also very many designers, engineers, calculators, scientific workers, test pilots, and a number of others who, while not now occupying any administrative posts, creatively approached their work, demonstrated much valuable ini- /59
tiative, and went about their work with joy and enthusiasm.

Undoubtedly, their extensive auxiliary material in the appendix to the book in the form of statistical tables and the quite complete and carefully selected list of recommended literature will be of great benefit to the reader.

The previous books of A. M. Izakson found many readers among aviation workers interested in helicopters. For many, especially among youthful students, they have been a reference book for a long time.

Without a doubt the new book by A. M. Izakson will also be favorably received, will be highly evaluated, and will be a valuable contribution of its author to the future progress and blossoming of Soviet helicopter construction.

V. B. Shavrov

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